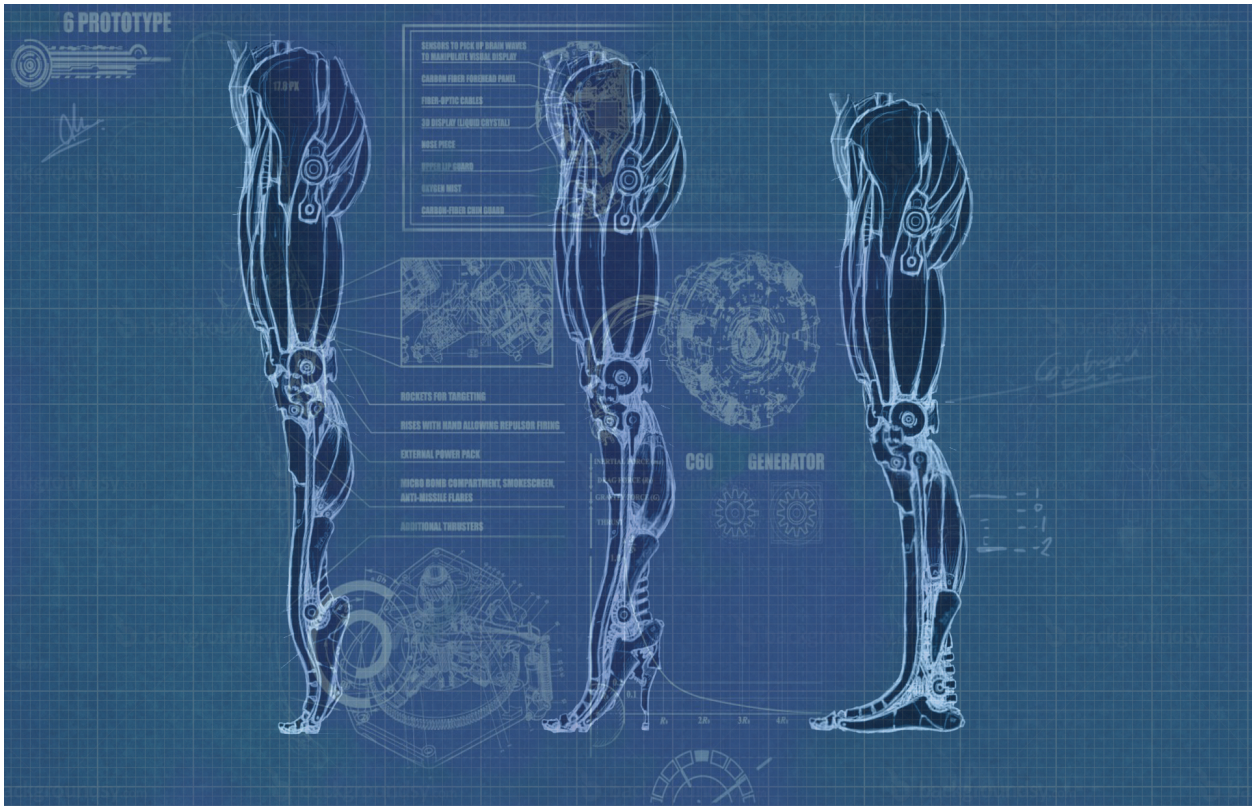
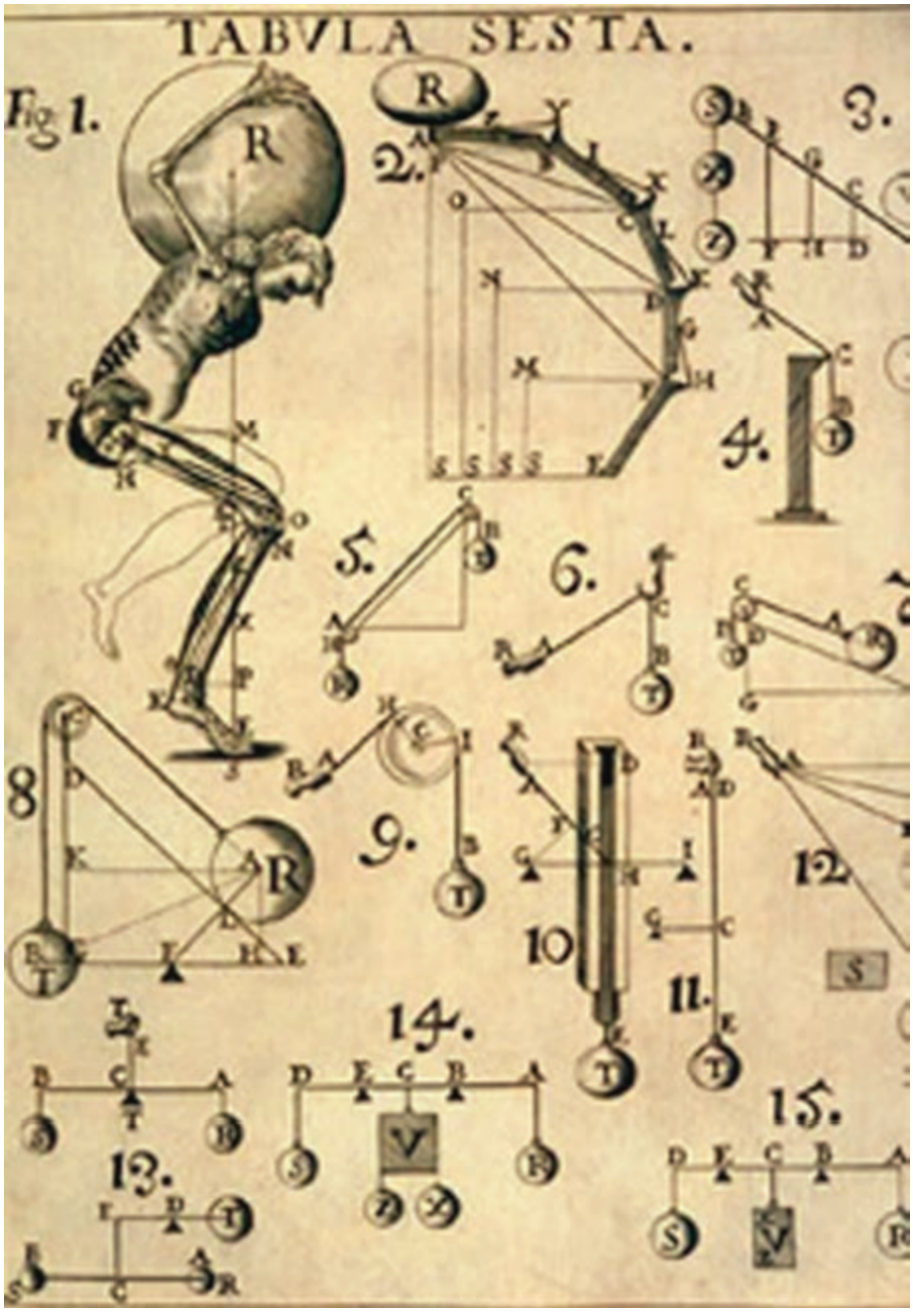


1.1 ELECTRODES

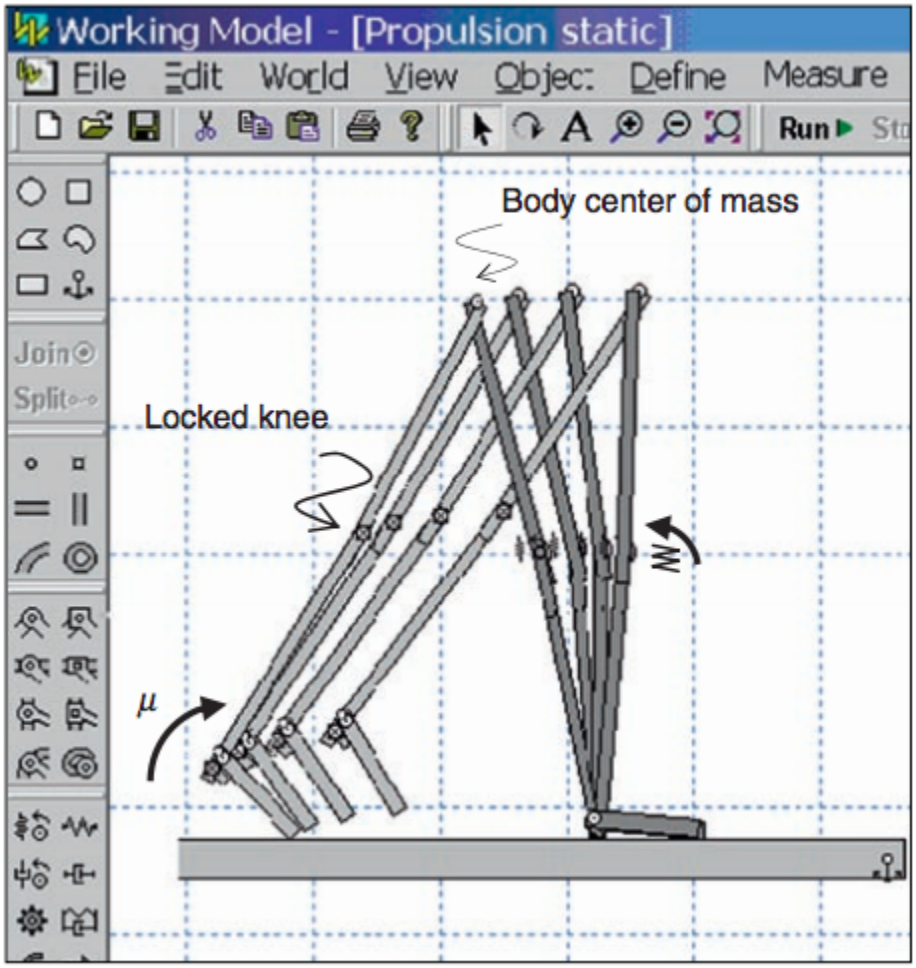
The first chronic recording electrodes were microwires. Developed over the last 40 years, these electrodes consist of fine wires 20 to 50 microns in diameter. They are generally composed of stainless steel or tungsten and insulated with teflon or polyimide. The tips may be etched or ground, but more often they are simply cut with a pair of scissors, leaving a planar recording surface. The wires can be arranged as arrays (for instance, in two rows of eight wires) by soldering them to a small connector (Williams et al. 1999, Nicolelis et al. 1999). Spacing between wires (100–300 microns) is maintained either with polyethylene glycol or methyl methacrylate. Wire arrays are surgically implanted in the anesthetized animal during a procedure that takes 8 to 10 h (rhesus monkey, four arrays, 64 electrodes). The cortex is exposed through a hole in the skull. After investigators remove the dura, the array is advanced slowly with a micromanipulator (100 microns/min) to minimize dimpling of the cortical surface. Although some anesthetics (i.e., ketamine) permit enough spontaneous or sensory-invoked activity in motor cortex to serve as an indicator of how far to advance the arrays, with gas inhalants such as fluorothane, spontaneous neural activity is not detectable with microwires in the motor cortex, making the optimal insertion depth uncertain. This uncertainty may leave the tips in a layer of cortex where it is difficult to record unitary activity and may be a key reason for subsequent recording failures. For exposed macaque cortex, the best depths are ≤2 mm below the surface. The shafts of the arrays are glued to the bone, so the depth of the electrode tip relative to the skull is permanently fixed. However, the cortical surface may move after the surgery, perhaps rebounding, if it had been dimpled, or shrinking, if swelling had taken place. The causes and dynamics of this phenomenon are not understood, but shrinking or expanding the brain, however slight, is a key issue because it will change the relative position of the electrode tip, perhaps moving it to different cortical layers or into the underlying white matter.



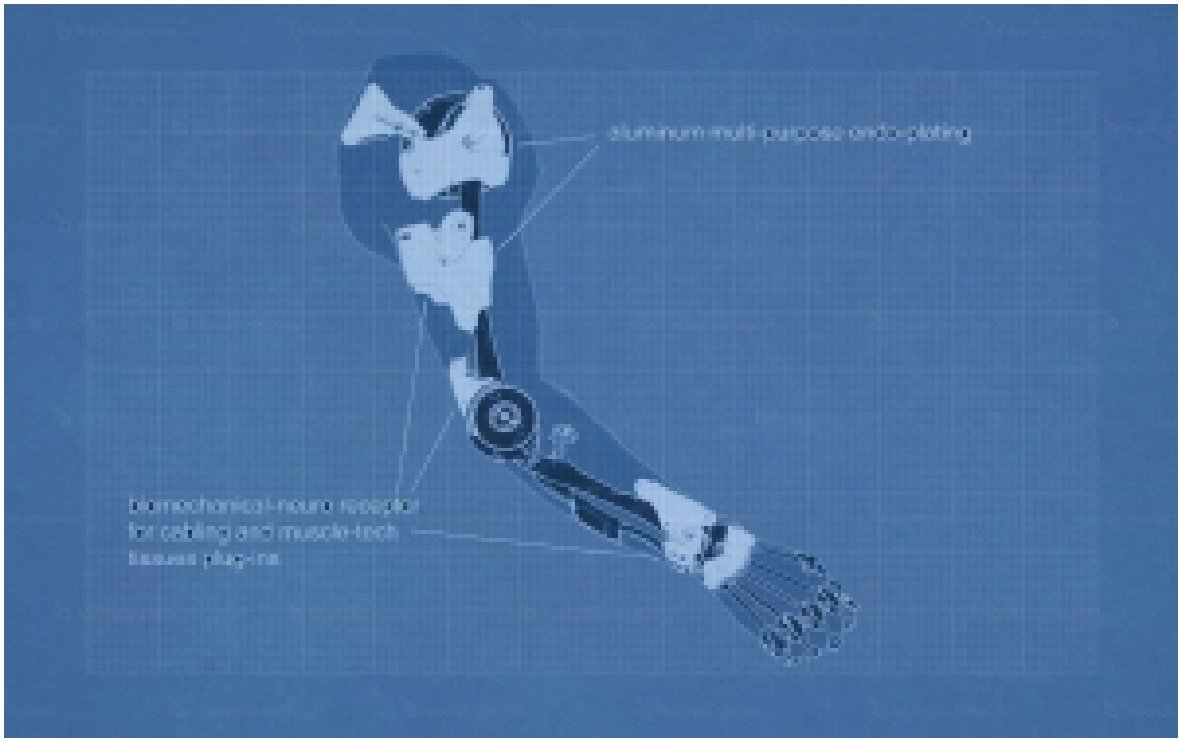
1.2 EXTRACTION ALGORITHM

To generate a prosthetic movement signal, information contained in the parallel recordings is transformed from the domain of spikes/sec to extrinsic (i.e.,
Cartesian) coordinates. Approaches for extracting information divide into two
broad categories: inferential methods and classifiers. Inferential methods are model
based—they depend on some understanding of underlying mechanisms. To illustrate this, we use a somewhat unrelated example from the vestibular system. The response generated by receptors in the semicircular canals to angular acceleration was predicted by modeling the endolymph, cupula, and canal as a torsional pendulum. On the basis of this mechanical model, the canal input, angular acceleration, is integrated to become angular velocity at the output. This model was confirmed by recordings of axonal activity in the eighth nerve, which were correlated with angular velocity. In contrast, classifier methods

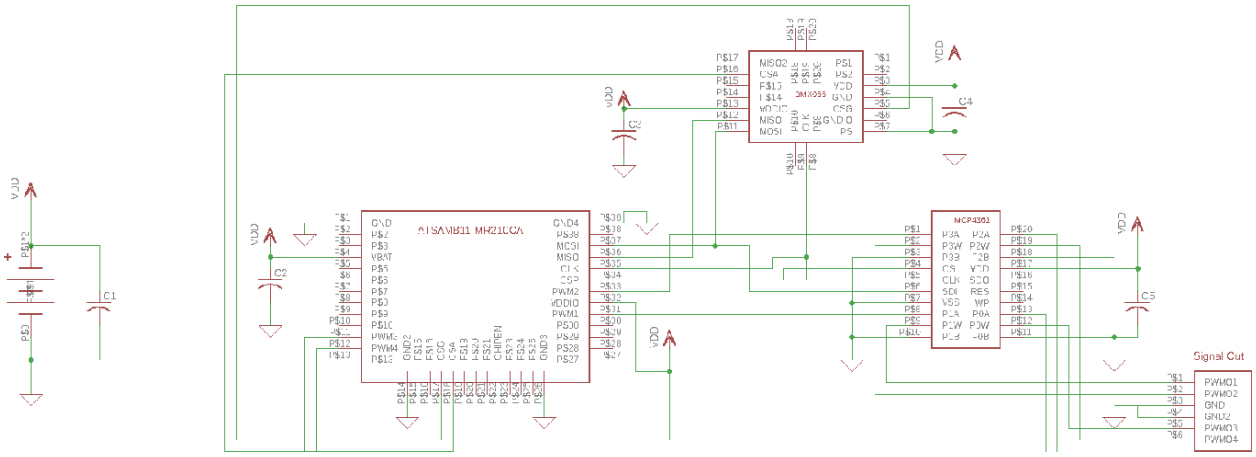
need not consider any mechanism. Rather they rely on a consistent representation of the parameter to be extracted. Imagine a set of three neurons recorded as a monkey moves to targets in eight directions. Considering each neuron as a binary element (on or off), these three neurons could encode each direction unambiguously.



Another simplified depiction of the above in a working simulation.



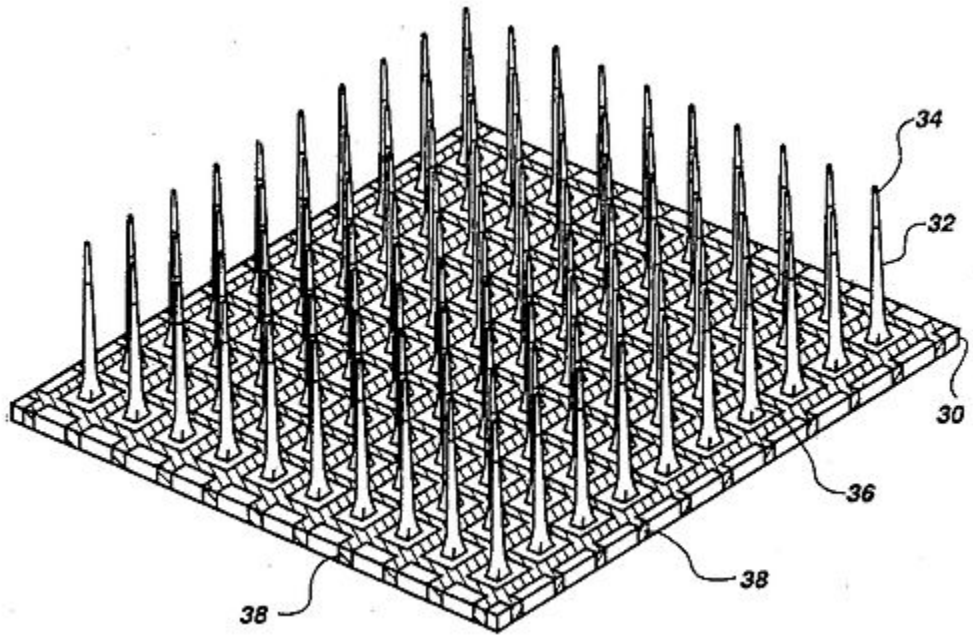
An overall schematic model for an internal prosthetic controlling a human arm.



This microcircuit platform, which models and controls neuromuscular pathways in insects, is instructive for replication of something similar on a larger scale in human bodies.

1.3 SAFETY

Catalyst of self destruction in extreme cases should be a requirement. (Sphinx#4903) The actual process can be several-layered, so that it can give authentication to only certain people on board.

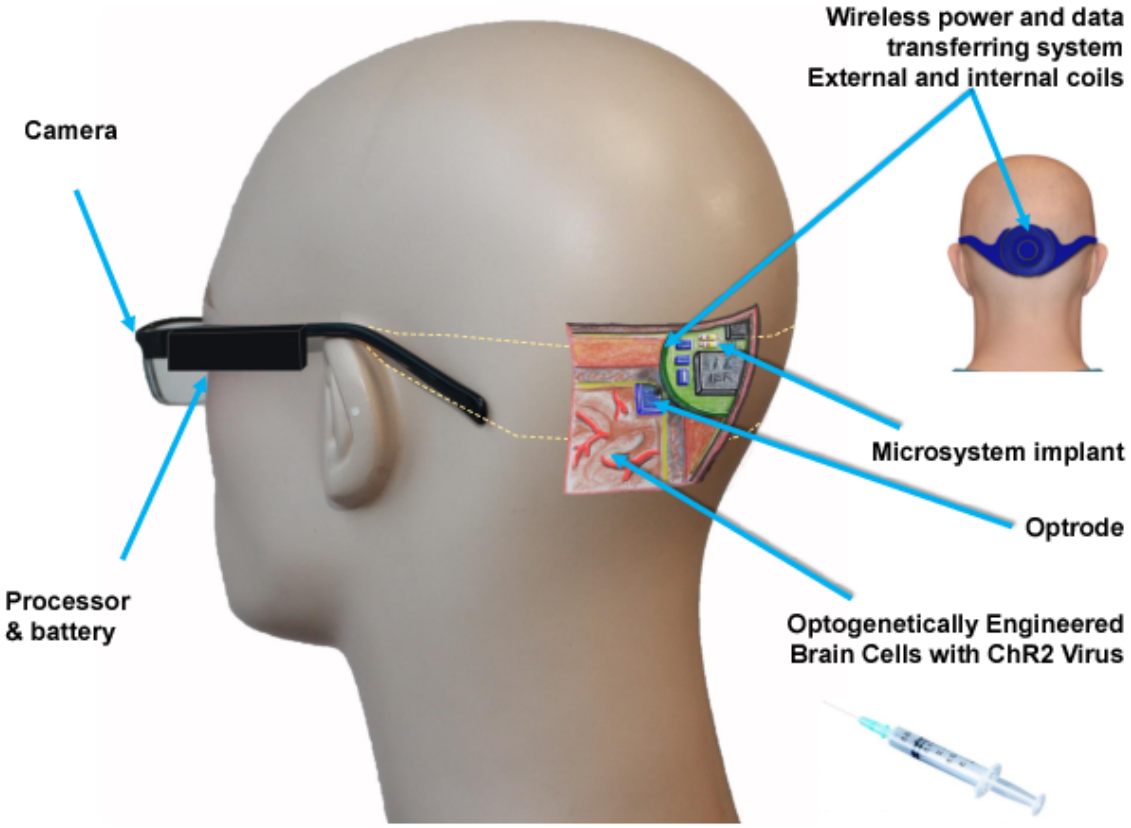


A typical neural implant employing Vagus nerve stimulation, which is increasingly becoming routine in patients with Parkinson's disease and clinical depression.

1.4 INTERFACE

Farwell and Donchin [9] described a BCI that exploited these properties of the oddball paradigm to allow a user to communicate a sequence of letters to a computer. An oddball paradigm was created by successively, and randomly, intensifying either a row or a column of a 6 by 6 matrix of characters that was displayed continually to the subject. In each "trial" the subject is "communicating" a character by focusing attention on the cell containing the character. Hence, the total sequence of events is divided into two categories. One category, which constitutes 16.7% of the intensifications (one in six), includes the cell whose content are at the focus of attention. The remaining intensifications are of rows and columns that do not include the relevant cell. If this is indeed an oddball paradigm, then the events containing the relevant cell (being the rare events in an oddball paradigm) should be the only events that elicit a P300. The communication task reduces, thus, to the detection of which row, and which column, are those eliciting a P300 on a given trial. The letter the

subject is trying to communicate is at the intersection of the row and the column that elicited a P300.



A bionic eye implant utilizing the ChR2 virus specimen for stimulation.